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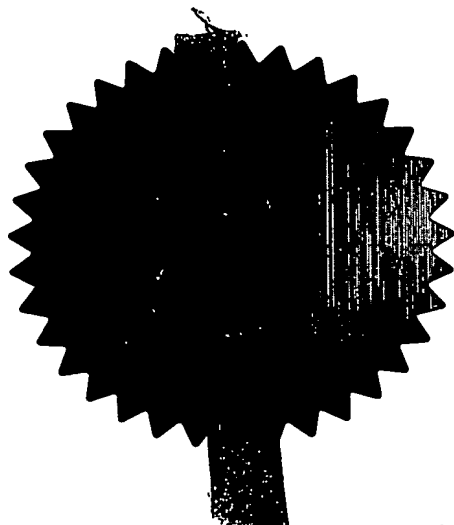
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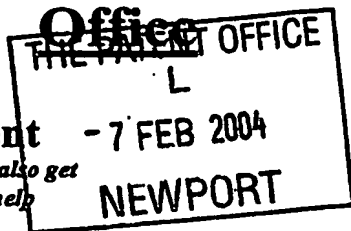
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2.	Patent application numberA (The Patent Office will fill in this part)	0402669.6		- 7 FEB 2004
3.	Full name, address and postcode of the or of each applicant (underline all surnames)	(1)	The University of Wales, Bangor The BioComposite Centre Bangor Gwynedd, LL57 2UW, UK 88 0439 5001	
	Patents ADP number (if you know it)	(2)	FIRA International Limited Maxwell Road Stevenage Hertfordshire, SG1 2EW, UK 88 044 11001	
	If the applicant is a corporate body, give the country/state of its incorporation	UNITED KINGDOM		
4.	Title of the invention	RECYCLING LIGNOCELLULOSE BASED BOARD MATERIAL		
5.	Name of your agent (if you have one)	Marks & Clerk	BOULT WADE TENNANT VERULAM GARDENS TO GRAY'S INN ROW LONDON WC1X 8BT 42.001	
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Description	7
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11. I/We request the grant of a patent on the basis of this application.

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## **RECYCLING OF LIGNOCELLULOSE BASED BOARD MATERIALS**

The present invention relates to the recycling of lignocellulose based board (or panel) material comprised of a matrix of adhesively bonded lignocellulosic elements so as to permit recovery of constituents of the board material, particularly but not exclusively of the lignocellulose.

It is well-known that various board materials comprise a matrix of lignocellulosic elements (e.g. in the form of chips, particles or fibres) bonded together by means of an adhesive such as a polyurethane, urea/formaldehyde, melamine-urea or phenolic resin. Examples of board materials produced in this way include MDF (Medium Density Fibreboard), particle board and chip board.

Board materials of the type described above are used extensively for producing finished articles such as furniture. For this purpose, the board materials are entirely satisfactory. However there is a substantial amount of waste material for which disposal poses a problem. To illustrate the point, the UK furniture manufacturing industry generates over 170,000 tonnes of MDF waste every year. This does not include rejected and damaged furniture items. Ideally the waste material would be recycled to recover constituents thereof, particularly the lignocellulose for reuse. However no satisfactory recycling process is currently available. The problem is made worse by the fact that the waste board material may be laminated to a surface layer such as paper foil or plastics (e.g. for decorative purposes) or may have plastic or metal inserts. As such, any recycling process will need to remove the laminates and/or inserts. In the absence of any suitable recycling process, most of the waste board material will be dumped in landfill site which is becoming more difficult and very expensive.

It is an object of the present invention to obviate or mitigate the above mentioned disadvantages.

According to the present invention there is provided a method of recovering a constituent of a board material comprised of a matrix of adhesively bonded lignocellulosic elements, the method comprising subjecting the material to a combination of (i) electromagnetic radiation having a frequency in the range 10 MHz to 300 GHz and (ii) soaking in water, and recovering the constituent.

The constituent to be recovered will generally be lignocellulose which may however incorporate residual resin, e.g. urea-formaldehyde resin.

The invention has been based on our discovery that treatment of board materials comprised of an adhesively bonded matrix of lignocellulosic elements (e.g. particles or fibres) by exposure to electromagnetic energy in the frequency range 10 MHz to 2500 MHz and soaking with water produces substantial swelling of the board material which, we believe, mechanically disrupts and possibly at least partially hydrolyses the adhesive bonding the lignocellulosic elements together so that these elements can now be readily separated from each other. The degree of swelling achieved is considerably more than that which is obtained simply by soaking the board material in water.

Steps (i) and (ii) may be effected simultaneously or sequentially. The degree of swelling achieved in the thickness dimension of the board should generally be in the range 3 to 6 times the original thickness.

Separation of the lignocellulosic elements from each other may be achieved using a relatively low degree of mechanical agitation whilst the treated material is in water. Once the elements have been separated, it is possible to recover a desired constituent of the board, which will usually be the lignocellulose. Thus, for example, the resultant dispersion of fibres may be dried, e.g. by press-drying (if the fibres are to be transported) or by a fan-assisted blowing system (if the fibres are to be re-used on site). Moreover, surface laminates (e.g. of paper, foil, melamine, veneer or other finishes commonly used on board materials to which the invention relates) can readily

be separated from the treated board prior to recovery of the fibres (e.g. by agitation) as may inserts or other bodies included in the panels.

The board material will typically have a density of  $200 \text{ Kg m}^{-3}$  to  $1200 \text{ Kg m}^{-3}$ .

The invention is applicable to a wide variety of wood based boards, including particle boards and fibre boards. Specific examples of board materials to which the present invention is applicable include MDF, chip board, hard board, soft board, orientated strand board, flax board and wood chip board.

The invention is applicable both to industrial- and consumer- waste board material.

The electromagnetic radiation used in the process of the invention has a frequency in the range 10 MHz to 300 GHz, preferably 10 MHz to 2500 MHz. The power is preferably in the range 500 W to 30 kW (more preferably 3 kW to 15 kW, although certain values in these ranges may be more applicable to some materials rather than others. Thus, for example, the power used should not be so high as to cause charring of the board material. The optimum parameters may readily be determined by a person skilled in the art.

It is particularly preferred that microwaves in the frequency range  $896 \pm 20$  MHz to  $2450 \pm 25$  MHz (such as generated by a magnetron) are employed. Thus, for example, the electromagnetic radiation used may be  $896 \pm 20$  MHz or  $2450 \pm 25$  MHz, both of which are frequencies reserved for domestic/industrial microwave use. The microwaves may be generated by means of a magnetron in a conventional way.

Alternatively the electromagnetic energy may have a frequency in the range 10 MHz to 50 MHz.

The invention may be practised in a number of ways. In a particularly preferred embodiment, the board material is initially subjected to the electromagnetic radiation and is then immersed substantially immediately into water (e.g. within 5 to 15 seconds), most preferably at elevated temperature (e.g. 60°-90°C, preferably about 80°C). For this embodiment, it is desirable that the board material does have internal moisture content, preferably a minimum of 8%, which may if necessary be enhanced prior to the treatment with electromagnetic radiation. Immersion of the board material that has been subjected to electromagnetic radiation into water causes substantial swelling to occur. Typically the exposure time to the electromagnetic radiation will be in the range of 30 to 90 seconds. Subsequently the material is soaked in water to swell the material. Typically the degree of swelling may be to 3 to 6 times the original degree of thickness, for which an immersion time of 10-25 minutes in water may be required, although the exact time will depend on factors such as the nature of the board, the parameters employed (e.g. frequency and power) employed during the treatment with electromagnetic energy and temperature of the water.

Any surface laminate applied to the board may easily be removed from the swollen board (and in fact the laminate may start to peel-off during the treatment with electromagnetic radiation). Similarly any inserts may also be removed easily. The swollen material may then readily be converted to a fibrous suspension (e.g. using a moderate degree of agitation such as provided a low power mechanical blender.

The fibrous suspension may then be dried, e.g. by press-drying or by means of a fan assisted blowing system as described previously.

This embodiment of the invention may be effected on a continuous or semi-continuous basis by, for example, passing the material to be treated through or passed a microwave source (with the material, for example, being on a conveyer belt) and then introducing the material into a tank of water for the desired residence time therein.

In an alternative, but less preferred, embodiment of the invention, the board materials is immersed in water and subjected to electromagnetic radiation as discussed previously followed by soaking in the water without erradiation. All other conditions being equal, this embodiment of the invention tends to produce a lower degree of swelling of the board than the above described preferred embodiment and does not lend itself as readily to continuous or semi-continuous operation as the above described preferred embodiment. It may however be possible to recover heat from the water (e.g. using a heat exchanger) to assist in drying of the board. Moreover, this embodiment involves not only heating of the board material by the electromagnetic radiation but also the water in which it is immersed, thus reducing energy efficiency. Furthermore, it is envisaged that this embodiment will provide more problems with effluent disposal than the above described more preferred embodiment.

For all embodiments of the invention, the board material may initially be subjected to a vacuum impregnation so as to increase its moisture content (e.g. up to 50% by weight). Alternatively or additionally the water in which the board is immersed may incorporate an additive (e.g. a surface active agent) to assist penetration of the water into the board.

Furthermore, for all embodiments of the invention, the board material may be "turned" during treatment with the electromagnetic radiation to ensure uniform exposure.

It will be appreciated that the invention is able to provide clean recycled fibre for a number of possible uses, e.g. production of other board products, wood plastic components, fillers and insulating materials.

The invention will be further described, by way of example only, with reference to the following non-limiting Examples and accompanying drawing which illustrates the result of Example 1.



**Example 1**

Two experiments were conducted as detailed under (a) and (b) below.

- (a) Samples of MDF measuring (50 x 50 x 18) mm were immersed (individually) in 1000 ml of water in a non-metallic container and subjected to microwave radiation at a frequency of  $2450 \pm 25$  MHz at power levels of 3 kW to 15 kW for a period of one minute. The samples were allowed to stand in the water for 10 to 15 minutes. The procedure was carried out a total of three times at each power level using fresh MDF samples each time. The thickness of the samples was measured after this treatment and the results plotted in Fig 1 which is a graph of the mean of the three thicknesses of the MDF samples (after the treatment) at each power level vs power level employed.
- (b) The procedure of (a) was repeated but using samples of MDF measuring (150 x 150 x 18) mm using power levels of 12 kW and 15 kW for a period of 60 seconds. The results are also plotted on Fig 1.

For the experiments of Parts (a) and (b), the water temperature was monitored and was found not to exceed 90°C

It can be seen from the results presented in Fig 1 that all samples swelled as a result of the combination of microwave treatment with simultaneous immersion in water. For the (50 x 50 x 18) mm samples, best results were obtained at power levels greater than 5 kW, with the samples swelling to a thickness of 60 mm or greater. The (150 x 150 x 18) mm samples provided even greater degrees of swelling. This finding could be indicative of "greater cavity loading" at higher power levels. Although not illustrated on the graph, a further sample of (150 x 150 x 18) mm board which was treated for 45 seconds at 12 kW power recorded a mean thickness swell of 92.11 mm.

All samples of the swollen material could easily be converted to a fibrous suspension in either approximately two minutes using a pulp disintegrator rated at 1.5 kW or in approximately four minutes using a 700 W laboratory stirrer.

### Example 2

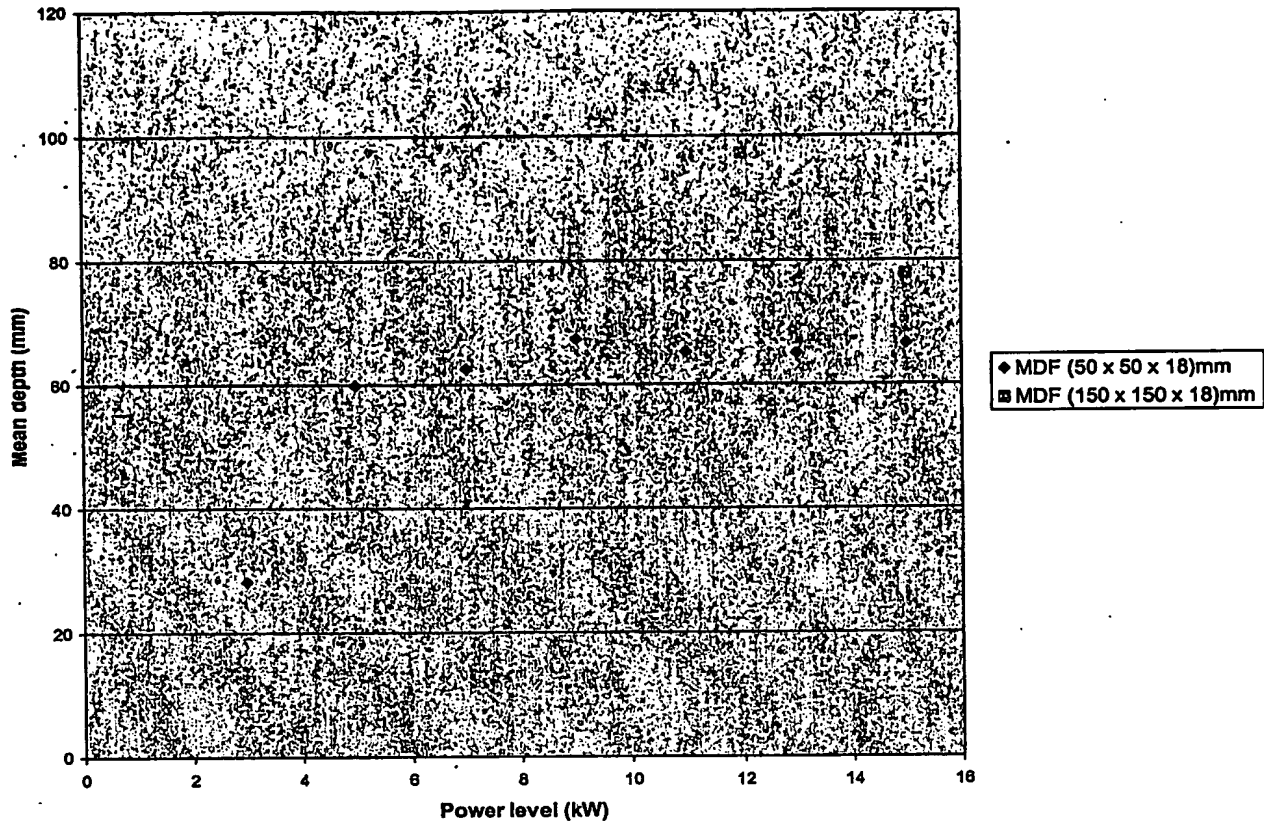
A (150 x 150 x 18) mm sample of MDF was subjected to microwave radiation at a frequency of  $2450 \pm 25$  MHz at a power level of 12 kW for a period of 45 seconds and then added immediately to water at a temperature of above 60°C and allowed to stand for 10 to 15 minutes.

The MDF was found to have swollen in thickness to 90.42 mm. The swollen material could easily be converted to a fibrous suspension in either approximately 2 minutes using a pulp disintegrator rated at 1.5 kW or in approximately 4 minutes using a 700 W laboratory stirrer.

### CLAIMS

1. A method of recovering a constituent of a board material comprised of a matrix of adhesively bonded lignocellulosic elements, the method comprising subjecting the material to a combination of (i) electromagnetic radiation having a frequency in the range 10 MHz to 300 GHz (ii) soaking in water, and recovering the constituent.
2. A method as claimed in claim 1 wherein the electromagnetic energy has a frequency in the range  $896 \pm 20$  MHz to  $2450 \pm 25$  MHz.
3. A method as claimed in claim 2 wherein the electromagnetic radiation has a frequency of  $896 \pm 20$  MHz.
4. A method as claimed in claim 2 wherein the electromagnetic radiation has a frequency of  $2450 \pm 25$  MHz.
5. A method as claimed in claim 1 wherein the electromagnetic radiation has a frequency in the range 10 MHz to 50 MHz.
6. A method as claimed in any of claims 1 to 5 wherein the power of the electromagnetic radiation is in the range 500 W to 30 kW.
7. A method as claimed in any of claims 1 to 6 wherein the board material is initially subjected to the electromagnetic radiation (step (i)) and then immersed in water (step (ii)).
8. A method as claimed in claim 7 wherein the water is at elevated temperature.
9. A method as claimed in claim 8 wherein the water is at a temperature of 60° to 90°C.
10. A method as claimed in any one of claims 1 to 6 wherein the board material is immersed in water and subjected to the electromagnetic radiation whilst immersed.

11. A method as claimed in any one of claim 1 to 10 wherein the treated board material is subjected to mechanical agitation in water to produce a fibrous suspension.
12. A method as claimed in claim 11 when lignocellulose is recovered from the fibrous suspension.
13. A method as claimed in claim 12 wherein the lignocellulose is recovered by drying of the suspension.
14. A method as claimed in any of claims 1 to 13 wherein the lignocellulose based board is a particle board or fibre board.
15. A method as claimed in claim 14 wherein the lignocellulose based board is Medium Density Fibreboard.

**Figure 1**

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